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THE STRUCTURAL RELATIONS OF SOME DEVONIAN SHALES IN CENTRAL NEW YORK.

BY BURNETT SMITH.

The shale mass which intervenes between the Onondaga and Tully limestones of central New York was formerly separated into a lower division of Marcellus shales and an upper division of Hamilton shales. It is now pretty generally conceded that this classification is inadequate to express the facts and the geologists of the State of New York now employ Marcellus shale, Cardiff shale, Skaneateles shale, Ludlowville shale, and Moscow shale in describing the stratigraphic units encountered in passing upward from the Onondaga to the Tully. These shale units by inference correspond with definite subdivisions of the Devonian time scale. They are also regarded as possessing a rather wide east and west distribution across the State.[1] Recent field studies in Onondaga and Cayuga Counties have convinced the writer that the lower members of the shale mass have a far from simple history. Followed in an east and west line they present changes which remain unrecognized even in the recent classifications. These notes are therefore submitted as a partial record and preliminary interpretation of the observations made.

A brief survey of the general stratigraphy brings out the fact that the shales have been deposited upon Onondaga limestone. In some places the line between the Onondaga and the succeeding black shale is quite sharp, but at others there is a transition zone of limestone and black shale alternations in thin bands. Great variations in the amount of limestone intercalation are noticed in the 10 or 15 feet just above the Onondaga. One limestone stratum, however, is shown in all good exposures. This layer known as the Agoniatites limestone is about 3 feet in thickness and holds a position approximately 10 or 15 feet above strata which are referable to the Onondaga. Lying thus upon black shale or upon black shale and limestone alternations the Agoniatites limestone is in turn followed by a deposit of dense black shale in which concretions of large size are apt to be a very conspicuous feature. This higher black shale is now grouped with the other layers down to the Onondaga under one formational term, Marcellus.[2]

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[1] N. Y. State Museum Handbook 19, Table 2.

As used by Vanuxem,[3] the term Marcellus apparently embraced a still higher shale of gray color. This latter was given a separate name by Clarke and Luther who in 1904 called it the Cardiff shale.[4] In the type region (on the Tully quadrangle) the change from the Marcellus is most gradual while above the Cardiff is defined as terminating some 20 feet below a thin band of limestone.[5] This limestone is grouped with the 20 feet of shale below and some hundreds of feet above under a single formational term, Skaneateles.

These general stratigraphic relations appear to hold good for central Onondaga County, but on tracing the formations westward deviations from the type section are noticed. It is now proposed to present the evidence for these deviations.

Just south of Mottville, on the Skaneateles quadrangle, occurs a fossiliferous zone which is well displayed along the outlet of Skaneateles Lake. The section at this point shows a thickness of about 25·feet. In the lower part the shale is gray and thinly bedded with small fossils numerous. Above come small concretions and a limy band full of crinoid fragments. This latter is in turn overlaid by a rather coarse and thickly bedded shale, also quite fossiliferous.[6] These strata are not here exposed in continuous section with any easily recognized reference plane. It was with the intention of ascertaining their position in the shale mass that the writer undertook to follow these beds east and west from the Mottville locality.

For the sake of simplicity the term Mottville member will be used as a provisional designation for the limy crinoidal band and associated fossiliferous shales above and below which are exposed along the Skaneateles outlet south of Mottville.[7] This member can be readily recognized by its lithologic and paleontologic characters for a few miles east and west from the type section. Eastward there is some slight change in its features, but the horizon can be traced with little difficulty onto the Tully quadrangle where the writer considers it to be identical with the basal layers of the Skaneateles formation up to and slightly above the limestone band already mentioned.[8]

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[2] N. Y. State Museum Bulletins 63, p. 14, and 82, pp. 42, 43.

[3] Nat. Hist. of N. Y., Geology, III, comprising the Survey of the Third Geological District, 1842, pp. 146, 147.

[4] N. Y. State Museum Bulletin 63, p. 16.

[5] N. Y. State Museum Bulletin 82, pp. 45, 46.

[6] These layers were apparently well known to Vanuxem; see *Geology of the Third District*, p. 154. Speaking of Cayuga Lake, he says: "The first rock going south on the lake, after passing the low clayey ground to the south of Springport, may be considered as the dividing line between the Marcellus shales and the Hamilton group. It is a dark slaty fossiliferous shale, with numerous individuals of the Orthis umbonata of Mr. Conrad, but usually small, associated with the Limitary orthis (O. limitaris) also numerous, etc. It shows about six feet of a brownish black impure limestone. This part forms the small rise about half a mile or more below Levana. It appears in the road from Springport to Levana, at Crise's brook; on the road to Auburn from Springport, two miles southwest of Half-acre; to the northeast of Skaneateles on the road to Marcellus, and on the north side of Pompey hill, etc."

Though this description makes no mention of the Mottville locality, it shows quite clearly that its author was familiar with many of the other good exposures of these strata.

The presence of a thin fossiliferous zone between masses of relatively barren shale is usually regarded as a matter of some paleontologic interest and the Mottville is no exception in this respect. It was not, however, until the writer studied the relations of this member to underlying formations westward that he realized the important position which the Mottville holds in any attempt to solve the stratigraphy of the lower shale units.

Its authors recognized that the Cardiff shale thins toward the west, a statement to that effect appearing in their description of the type sections.[9]

Nevertheless, the writer confesses that he was much surprised to learn in the field that the gray shales between the harder limy portions of the Mottville and the black Marcellus thin down to about 100 feet southeast of the village of Marcellus (Skaneateles quadrangle), to about 50 feet in the belt south of Shepard Settlement, to about 25 feet near the western limit of the Skaneateles quadrangle, and to about 15 feet on the eastern shore of Cayuga Lake (Auburn quadrangle).

As stated above, the top of the Cardiff in the type locality has been defined by its authors as being 20 feet below a limestone band in their Skaneateles. The writer regards this limestone band as the equivalent of the upper limy portions of the Mottville, and if this correlation is correct there is very little room for a Cardiff formation between the harder Mottville and the Marcellus of the Auburn quadrangle. It is therefore believed that (in the absence of positive diagnostic characters) the Cardiff shale cannot be differentiated as a separate unit west of the Skaneateles quadrangle.

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[7] At the Mottville locality about 10 feet of shale are exposed below the crinoidal band. In other sections an additional 10 or 15 feet of fossiliferous strata are usually to be seen at the base. These latter beds, though not exposed at the type locality, are included in the term Mottville as used in this paper.

[8] The above refers to the Skaneateles formation as described by Clarke and Luther; see N. Y. State Museum Bulletin 82.

[9] N. Y. State Museum Bulletin 82, p. 45.

From the western boundary of the Skaneateles quadrangle to Cayuga Lake continuous sections are rare, but there is always some reference plane by which to check the position of the Mottville beds. In the same area there are also some slight variations in lithologic character, but these are clearly of a progressive nature, becoming more pronounced by slow degrees from east to west. Paleontologic characters are well maintained throughout the region in question and one more evidence of continuity is afforded by the escarpment which is frequently produced by the harder layers.

The more important sections met with in passing from the Tully quadrangle to Cayuga Lake are shown slightly idealized in Plate XXII.

Section 2 is exposed in a ravine situated west of Cottle Hill and about $\frac{3}{4}$ mile from the western limit of the Skaneateles quadrangle. The harder portions of the Mottville are well displayed at this locality and their position relative to the black Marcellus is beyond all question, for the section is continuous. About $1\frac{1}{8}$ miles southwesterly at nearly the same altitude and on the Auburn quadrangle is found another exposure of the Mottville crinoidal layer and associated shales. Here unfortunately the black Marcellus is not shown below in continuous section. It is exposed, however, at a lower altitude in a near-by ravine within $\frac{1}{4}$ mile to the west. The relation is the same as that shown in section 2. This easternmost Mottville exposure on the Auburn quadrangle is an important one. It can be connected by a nearly continuous escarpment with the Mottville layers of section 2. It agrees in its lithologic and paleontologic characters with other exposures of the Mottville. It lacks only a *continuous* section to prove its stratigraphic position above the Marcellus. These points are emphasized, for this Mottville exposure has apparently received a far different interpretation on the geologic map of the Auburn quadrangle.[10]

A little south of Half Acre and about $1\frac{3}{4}$ miles southwesterly from the Auburn city line a good exposure of the Mottville member is obtained. Here its position above the black Marcellus can be determined in a nearly continuous section while the relations with the Agoniatites limestone and the *Styliolina* layers below it are scarcely less clear.

Passing toward the southwest in the direction of Oakwood the limy character of the upper harder layers is pronounced. They stand out as a prominent escarpment for about 1½ miles between Half Acre and Oakwood.[11] East and a little south of Oakwood on the boundary line between the towns of Fleming and Springport another good exposure of Mottville is found. At the point where the roadway on the map is marked with an altitude of 707 feet the harder layers of the Mottville are finely displayed. As stated above, these harder layers undergo a certain amount of progressive change toward the west. They are now quite limy and of bluish shades which become lighter on exposure. Prolonged weathering produces a duller and more rusty appearance which, together with numerous "cauda-galli" markings, causes a curious resemblance to the very much higher beds which are usually assigned to the Ludlowville. At this town line exposure the relations with the Agoniatites limestone are again determinable, for the latter is exposed in a field south of the road which parallels the Lehigh Valley track.

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[10] N. Y. State Museum Bulletin 137. See map and also p. 18, where one finds the following statement: "The Agoniatite limestone and adjacent black shales outcrop $\frac{1}{2}$ mile from the east line of the quadrangle by the side of the third east and west road from the north line of the quadrangle."

At the four corners which lie about 1½ miles south and a little east of Oakwood the Mottville is again displayed and is connected by a fairly well-marked escarpment with the localities northeast. Here at these four corners the relations with lower strata can be made out, the Agoniatites limestone outcropping at the slight bend in the north-leading road ⅝ mile to the north, the Onondaga limestone and *Styliolina* layers by the roadside about ⅝ mile to the west. The writer wishes to emphasize the fact that his interpretation of the stratigraphy between Half Acre and these four corners is based on evidence furnished (1) by lithologic and paleontologic similarity of the different Mottville exposures, (2) by the position of each exposure with reference to some easily recognized lower stratum and (3) by the occurrence of the exposures on the edge of a hard rock platform which frequently displays a well-marked escarpment on its northern and northwestern fronts. These lines of evidence lead to a conception of the stratigraphy, which is quite different from that shown on the geologic map of the Auburn quadrangle.[12]

On approaching Cayuga Lake the harder portion of the Mottville produces the falls just east of the lake road in Great Gully Brook and in the next brook south which is unnamed on the map.[13] This latter is apparently the Crise's Brook of Vanuxem and is called

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[11] See Vanuxem, *Geology of the Third District,* p. 154.

[12] N. Y. State Museum Bulletin 137.

[13] See Cleland, U. S. G. S. Bulletin 206, pp. 22, 23, and also Luther, N. Y. State Museum Bulletin 137, p. 19.

Criss Creek by Luther whose interpretation of its section seems to be as follows: The hard layer producing the falls near the lake road bridge is "Near the top" of the "Cardiff." A "gray fossiliferous band at the base of the formation" which occurs at the private road crossing farther north is attributed to the horizon of the Stafford limestone of western New York.

The present writer's interpretation of the same section may be summarized in this way: The hard layers making the falls near the lake road bridge are the upper limy portion of the Mottville. They are underlaid by about 15 feet of gray shale rich in small fossils. These latter are the lower soft shales of the Mottville and are considered the equivalent of strata which on the Tully quadrangle have been assigned to the Skaneateles by others. A short distance below the lake road bridge their contact with the underlying black Marcellus is well displayed. The "gray fossiliferous band" exposed near the private road crossing farther down stream is not connected by continuous section with the Mottville at the lake road bridge. It has the same lithologic and paleontologic characters as the lower 15 feet of Mottville at the lake road bridge. It is also immediately overlaid by material indistinguishable from the harder Mottville, while a short distance still farther down stream another exposure of typical Marcellus is found. It is believed that the lakeward dip which is plainly visible in places and a slight folding are responsible for the repetition of the strata.

This latter interpretation is amply confirmed by a study of the lake shore sections east and west of the Lehigh Valley track between Levanna and Farley's. It also appears to be in harmony with the section of the region which was published by Cleland in 1903.[14]

SUMMARY OF OBSERVATIONS.

The writer believes that the following points have been demonstrated:

(1) That the Marcellus black shale is continuous from the Tully quadrangle to the east shore of Cayuga Lake (as stated in substance by Vanuxem) and that it thins considerably to the westward.

(2) That the Cardiff shale, as defined by its authors, thins rapidly toward the west and becomes unrecognizable as a separate unit before the Auburn quadrangle is reached.

(3) That the Mottville member (basal Skaneateles of the Tully quadrangle) is continuous throughout the region, lying on the

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[14] U. S. G. S. Bulletin 206, p. 21, fig. 2.

Cardiff to the east, but overlapping it and coming in contact with the Marcellus to the west.

THEORETICAL CONSIDERATIONS.

If the points outlined above are admitted, a number of questions immediately arise. The first to be considered is this: How far westward does the overlap type of structure persist? If it extends to the western limit of the State involving each higher unit in turn, it is clear that younger and younger material will come to lie in contact with the basal black shale. Much depends upon the determination of the western equivalent of the Mottville. Should it prove referable to the Stafford limestone,[15] the present writer could not escape the conclusion that the Stafford of western New York is the equivalent of the lowermost Skaneateles of the central portions of the State. In such a case the Stafford of western New York separates not the Marcellus from the Cardiff, but the Marcellus from the bulk of the Skaneateles formation.

If, on the other hand, the overlap westward goes no farther than Cayuga Lake, we may be dealing with a north and south axis of Onondaga limestone, on each side of which the shale units are reproduced in a similar stratigraphic succession. Though this view is well within the bounds of possibility, it can hardly be said that the known examples of the Onondaga-Marcellus contact furnish evidence in its support.

Opportunity has not yet been found for anything like a thorough paleontological study of the Mottville beds. The species so far identified reveal a fauna not unlike that of the Stafford. It is believed, however, that correlation based upon fossils alone is most unsafe in determining the position of these Mottville strata.

Returning to the stratigraphic aspects of the problem, it may be said that overlap in the structural sense can hardly be questioned.

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[15] In this connection see N. Y. State Museum Bulletin 49, p. 120, where occurs the following statement by Dr. John M. Clarke:

"In the outcrops along Criss creek, 2½ miles south of Union Springs, the strata above the horizon of the Agoniatite limestone are shown, and a point of interest in this section is the presence of a bed of 15 feet of blue and olive calcareous shales, lying above the general mass of darker shales, which carries certain trilobites (*Homalonotus*, *Phacops*), brachiopods, gastropods, etc. pertaining to the normal Hamilton shale fauna. These shales lie at about the proper horizon of the Stafford limestone, though no trace of this rock has been seen so far east."

There can be little doubt that Dr. Clarke is describing the upper limy portions of the Mottville which are exposed in this creek. It is perhaps unnecessary to add that, in the matter of Stafford correlation, one could hardly look to a more authoritative source.

That is (1) a fossiliferous zone is separated from a black shale by a bed of barren gray shale, (2) followed west the fossil zone is seen to approach nearer and nearer to the black shale in successive sections, (3) at the west the fossiliferous zone lies immediately above the black shale.

Such relations at least suggest an unconformity somewhere in the series. The writer has, however, failed to discover positive evidence of one in passing from the Onondaga to the Mottville. It is true that the base of the Mottville limy layer is frequently very uneven. The same observation likewise holds for the Agoniatites limestone. Both cases are, however, regarded as due to a concretionary structure; limy segregations merely pushing downward into the strata below.

When considered in relation to the general black shale problem, it is believed that the data obtained in this area go to strengthen the theories which explain the Marcellus as an invasion from the east and south toward the north and west.[16] On the other hand, transgression over a land surface is somewhat questionable; in fact, the evidence rather points to a different conclusion. We are apparently justified in regarding the Marcellus as a formation which, so to speak, runs diagonally across the geologic column, its lower layers and more eastern portions being contemporary with some Onondaga to the west while its upper and more western portions were probably deposited at a time when Cardiff sedimentation was occurring to the east.

Evidence presented by Kindle[17] shows that black shale (presumably Marcellus) deposition in the Allegheny region was taking place at the same time with Onondaga accumulation. For the particular area here studied it is sufficient to call attention to the thin black shale intercalations which are found in the Onondaga south of Union Springs. The very gradual transition from Marcellus to Cardiff and the general structure outlined in these notes both argue for partial contemporaneity between Cardiff and Marcellus.

Explanation of Plate XXII.

Diagram showing the stratigraphic relations exhibited by the Mottville member in passing from Cayuga Lake on the west to the Tully quadrangle on the east.

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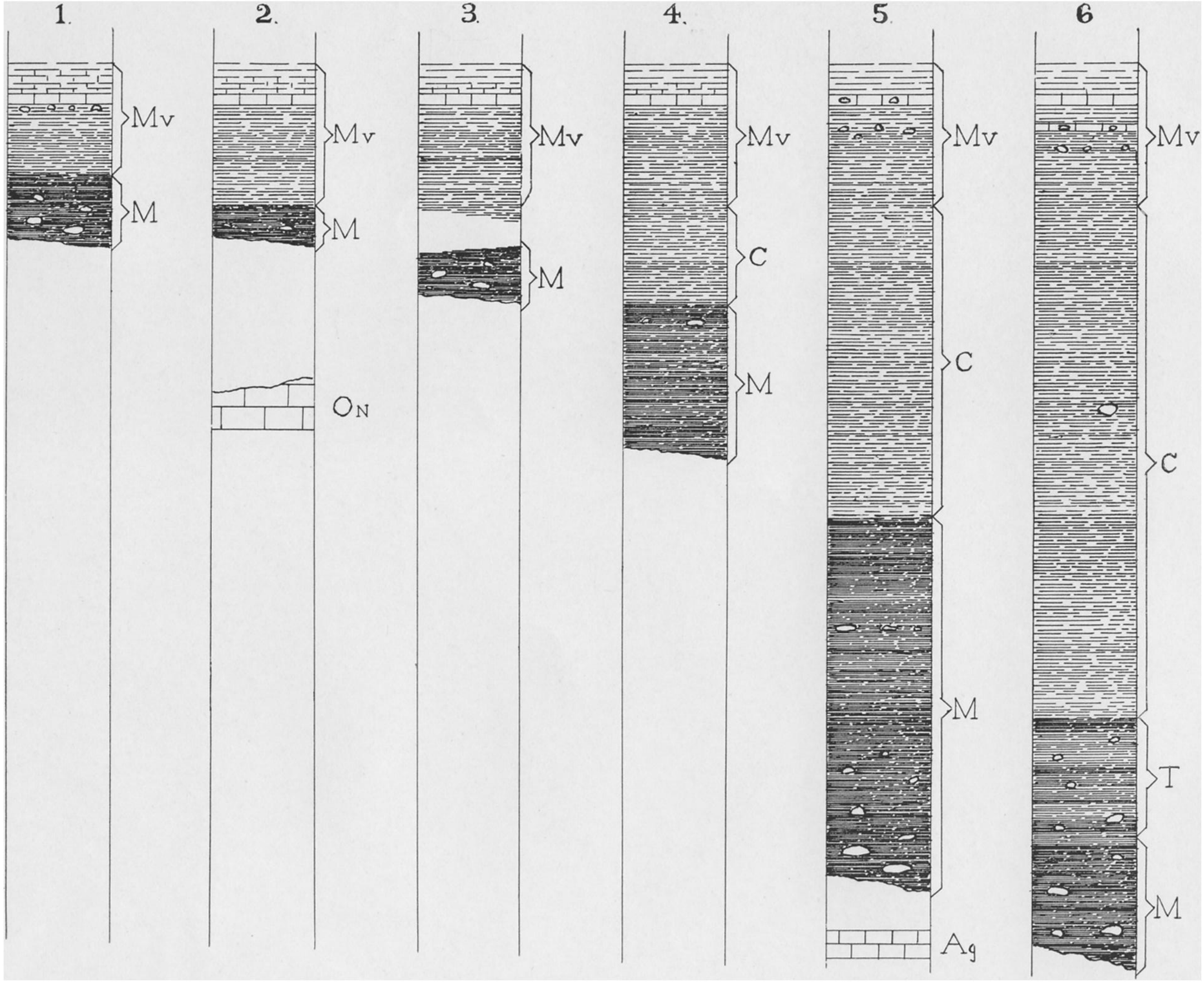
[16] Clarke, John M., N. Y. State Museum Bulletins 49 (pp. 115, 137) and 52 (pp. 668–9).
Ulrich, E. O., and Schuchert, Charles, N. Y. State Mus. Bul. 52, p. 665.
Grabau, A. W., N. Y. State Mus. Bul. 92, p. 231.
"Principles of Stratigraphy," pp. 407, 424.

[17] Kindle, E. M., U. S. G. S. Bulletin 508. See especially pp. 10, 25, 54.

Section 1 represents a thickness of about 40 feet of strata. Section 6 has been slightly reduced in order to bring it into the diagram.

1. Composite section Criss Creek and shore of Cayuga Lake, Auburn quadrangle.
2. About ¾ mile from the western limit of the Skaneateles quadrangle.
3. Cottle Hill, Skaneateles quadrangle.
4. Composite section about 2½ miles northeast of Skaneateles Village.
5. About 1¼ miles southeast of Marcellus Village, Skaneateles quadrangle.
6. Boundary between Skaneateles and Tully quadrangles. Mv. = Mottville member (shales and limestone); C. = Cardiff shale; M. = Marcellus shale; T. = Marcellus-Cardiff transition; Ag. = Agoniatites limestone; On. = Onondaga limestone.



BURNETT SMITH: DEVONIAN SHALES OF CENTRAL NEW YORK.